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PENSOFT

First record of the goo-eater snake, *Geophis nigroalbus* Boulenger, 1908 (Serpentes, Dipsadidae), in the Magdalena Valley, Cordillera Oriental of Colombia

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Abstract
Geophis nigroalbus Boulenger, 1908 is a fossorial and secretive colubrid snake endemic to the western Andes of Colombia. Here we report this species for the first time in the Cordillera Oriental in Middle Magdalena Valley. We expand the known distribution of *G. nigroalbus* 183 km east of its original range.

Keywords
Boyacá, Colubridae, endemic, range extension.

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Introduction

The genus *Geophis* Wagler, 1830 contains 50 known species of semi-fossorial snakes (Canseco-Márquez et al. 2016; Uetz et al. 2019), making it one of the most diverse colubrid genera in the western hemisphere (Wilson and Townsend 2007). This genus is principally distributed in Middle America, from northern Mexico to western Panama, between 13–2744 m a.s.l (Myers 2003; Wilson and Townsend 2007; Canseco-Márquez et al. 2016). The western Andes of Colombia presents two endemic species: *G. nigroalbus* Boulenger, 1908 and *G. betaniensis* Restrepo & Wright, 1987, with a possible third species, *G. hoffmanni* (Peters, 1859), which may also reach this region (Myers 2003; Wilson and Townsend 2007). The secretive fossorial habit of these snakes makes them difficult to find in the field and is the reason for the few specimens deposited in herpetological collections: 41 specimens of *G. nigroalbus* and two specimens of *G. betaniensis*.

Based on morphological characters, Downs (1967) subdivided the genus into seven species groups: 1) *chalybeus* 2) *championi* 3) *dubius* 4) *latifrontalis* 5) *omiltemanus* 6) *semidoliatus*, and 7) *sieboldi*. The last contains the greatest number of species (n = 17) (Savage and Watling 2008). Among the *G. sieboldi* group, the *G. brachycephalus* species complex has recently received attention with the resurrection of *G. nigroalbus,*

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previously treated as a synonym of *G. brachycephalus* (Cope, 1871), and the inclusion of the following species: *G. brachycephalus*, *G. talamancae* Lips & Savage, 1994, *G. tectus* Savage & Watling, 2008, and *G. nigroalbus* (Myers 2003; Savage and Watling 2008).

Geophis nigroalbus was first described by Boulenger (1908) based on a specimen from Pavas, a locality in La Cumbre, Valle del Cauca (Fig. 1, Site A; Table 1) on the western slope of the Cordillera Occidental of Colombia. Since then, *G. nigroalbus* has been rarely found in biological collections and is known from only two additional localities (34 specimens in Betania, Valle del Cauca (Fig. 1, Site B; Table 1) and a single specimen (BMNH 98.10.27.3) in Santa Rita, Antioquia (Fig. 1, Site C; Table 1). Here we add three more localities and extend the known distribution of the species to the western slope of the Cordillera Oriental in the middle region of the Magdalena Valley.

Methods

The study area is a fragment of tropical wet forest in the municipality of Puerto Boyacá, Boyacá Department, Vereda Quinchas at an elevation between 1200 and 1300 m a.s.l. The individual was captured by hand at night during visual encounter surveys (VES) (Crump and Scott 1994). Photographs of the cephalic and dorsal region were taken in life with a Canon 5D Mark III (Fig. 2). The specimen was euthanized with a cardiac injection of xylocaine 2% (Mustafa and Zlateva 2018). A liver sample was taken post-mortem and the specimen was fixed in 10% analytic formalin. Standard measurements

Table 1. Localities with confirmed records of *Geophis nigroalbus* in Colombia. The sites are represented at the distribution map in Figure 1.

Site	Department	Municipality	Locality	Latitude	Longitude	Elevation a.s.l. (m)	Reference
A	Valle del Cauca	La Cumbre	Pavas	03°41′ N	076°35′ W	1390	Savage and Watling 2008
B	Valle del Cauca	Bolivar	Betania	04°26.23′ N	076°18.56′ W	1743	Savage and Watling 2008
C	Antioquia	Andes	Santa Rita	05°36.79′ N	075°54.99′ W	1600	Savage and Watling 2008
D	Risaralda	Pueblo Rico	–	—	—	1600	This study
E	Antioquia	Frontino	Pantanos	06°43.61′ N	076°31.85′ W	1037	This study
F	Boyacá	Puerto Boyacá	Las Quinchas	05°50.03′ N	074°16.12′ W	1250	This study

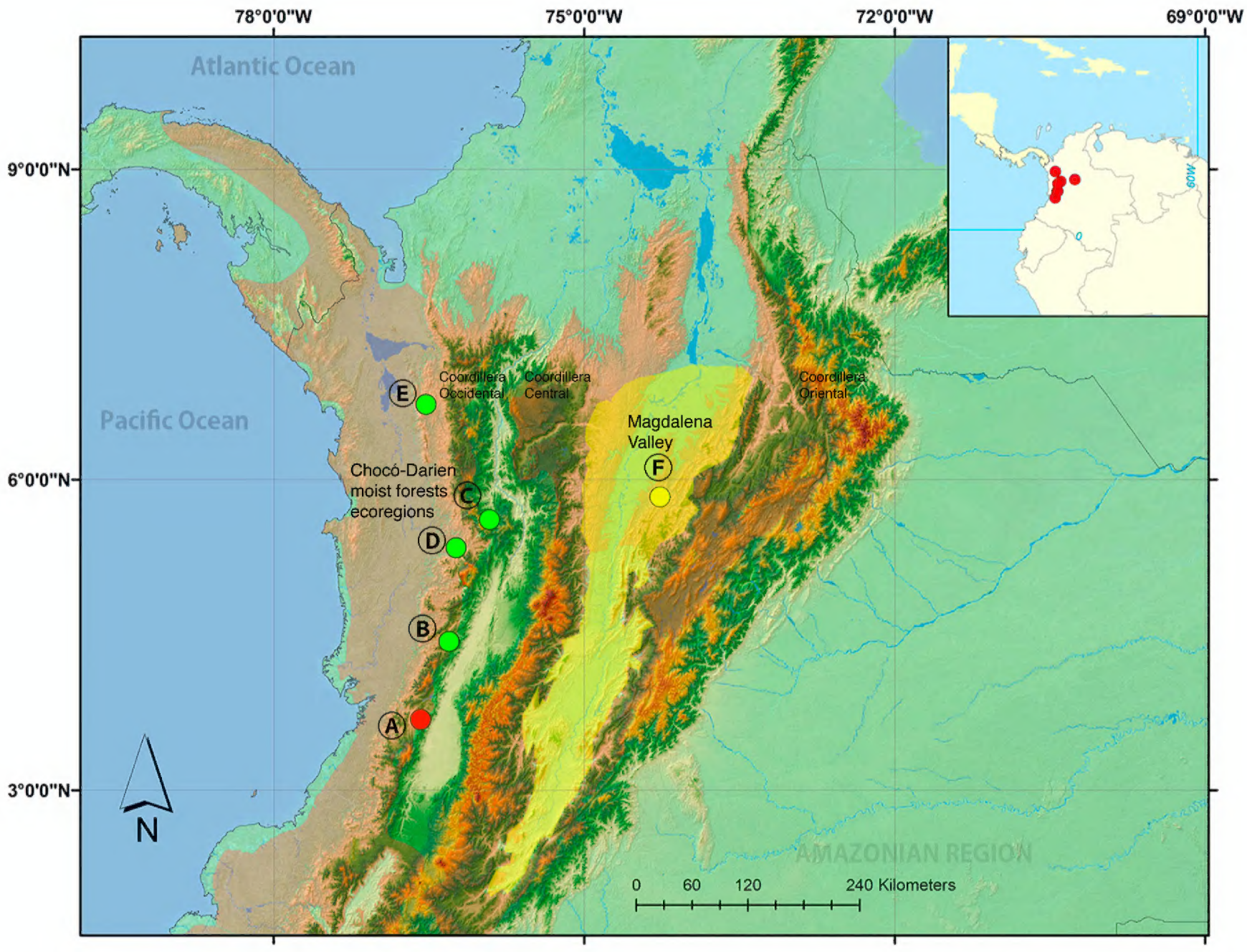

Figure 1. Geographic distribution of *G. nigroalbus* in Colombia: A = type locality (red dot), published in the original description by Boulenger (1908), Valle del Cauca Department; B = Municipality of Betania, Valle del Cauca Department; C = Municipality of Santa Rita, Antioquia Department; D = Municipality of Pueblo Rico, Risaralda Department (ICN 10710); E = Municipality of Frontino, Antioquia Department (IAvH-R-8602); F = new record, Puerto Boyacá Municipality, Boyacá Department, Vereda Las Quinchas, IAvH-R-9257 (yellow dot). The brown area between the Coordillera Occidental and the Pacific corresponds to the Choco-Darien moist forest ecoregion and yellow intermontane area corresponds to the Magdalena Valley region (*sensu* Olson et al. 2001). Map constructed using Arc Map v. 10.2.1.

of snout-vent length (SVL) and tail length (TL) were taken using a measuring tape. Morphological characters were recorded following Downs (1967). Taxonomic identification of the species is based on Savage and Watling (2008). The updated map of the geographic distribution of *G. nigroalbus* was built using ARC-GIS version 10.2.1 based on this new record to the Cordillera Oriental, published records in the literature and the examination of two specimens in the zoological collections of Instituto de Ciencias Naturales of the Universidad Nacional de Colombia (ICN-MHN) and the Alexander von Humboldt Resources Biological Research Institute (IAvH-R). The specimen was collected under a permit issued by the Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (Decree 1376 of 2013).

Results

Order Squamata
Family Dipsadidae
Genus *Geophis* Wagler, 1830

***Geophis nigroalbus* Boulenger, 1908**
Figure 2

New record (Fig. 1). Colombia • 1 adult ♂, SVL:309 mm, TL:65 mm; Boyacá Department, Puerto Boyacá Municipality, Vereda Las Quinchas; 05°50.03′ N, 074°16.12′ W, 1250 m a.s.l; 1 Aug. 2019; Alejandro Corrales, Daniela Garcia, Gladys Cárdenas and Azarys Paternina leg.; IAvH-R-9257.

Material examined. Colombia • 1 adult ♀; Risaralda Department, Municipality of Pueblo Rico; 1600 m a.s.l; 16 Apr. 1991; ICN-10710. • 1 juvenile ♀, Antioquia Department, Frontino Municipality, Sector Pantanos; 06°43.61′ N, 076°31.85′ W, 1037 m a.s.l, 4 Jul. 2016; IAvH-R-8602.

An adult male of the semi fossorial colubrid snake *G. nigroalbus* was found actively foraging during the night of August 1, 2019 in a regenerative tropical rain forest. It was foraging in the leaf litter of the forest at 21:30 h after a strong rainfall of about one-hour duration. The specimen exhibits the typical behavior of semi fossorial snakes, attempting to escape with its head pointing downwards "digging" through the collector's fingers.

Identification. *Geophis nigroalbus* is a small species that shares the following combination of morphological characters with the *G. brachycephalus* species complex: supralabials six, two located posterior to the eye orbit, absence of anterior temporal scale, dorsal scale count 15-15-15, caudal scales strongly keeled; parietal scales separated from last supralabial by an elongate temporal scale (Savage and Watling 2008).

Geophis nigroalbus may be distinguished from the other species within this complex by the following combination of scale counts (*sensu* Savage and Watling 2008): ventrals 134–143.5 ± 3.8 in males and 141–148 ± 5.2 in females (129–140.05 ± 4.2 and 136–141.7± 2.5 in *G. brachycephalus*; 118–124.9 ± 3.7 and 121–128.8 ± 4.4 in *G. talamancae*; 137–138.5 ± 0.9 and 138 in *G. tectus*); subcaudals 42–46.3 ± 2.1 in males and 37–41.3 ± 2.8–46 in females (35–39.6 ± 3.4 and 29–33.5 ± 2.2 in *G. brachycephalus*; 35–38.1 ± 1.4 and 23–33.4 ± 2.3 in *G. talamancae*; 44–47.0 ± 2.4 and 43 in *G. tectus*).

Geophis nigroalbus is also distinguished from the other two sympatric Colombian species (*G. hoffmanni* and *G. betaniensis*) by the presence of distinctly keeled scales throughout the body except the neck region (smooth scales throughout the body in *G. betaniensis* and in *G. hoffmanni*), postocular one (two in *G. betaniensis*), supralabials six (five in *G. hoffmanni*) and post-temporal scale present (absent in *G. hoffmanni*). IAvH-R-9257 has the following combination of characters that clearly differentiate it from similar or sympatric species: dorsal scale count 15-15-15, postocular one, elongate posterior temporal, supralabials six, ventrals 147, and subcaudals 45. The first keeled dorsals appear at the level of the 20th ventral scale and extend posteriorly through the remainder of the body and tail; more than 85% of the body has keeled scales. The coloration is uniform black on dorsum and dorsal tail; the venter is cream with black spots; underside of tail black with a few cream patches; infralabials and chin are black (Fig. 2).

Discussion

This new record of *G. nigroalbus* represents the only confirmed species of *Geophis* that occurs east of the western Andes of Colombia, extending the known distribution of the species 183 km from the nearest known record. Although *G. nigroalbus* was previously only known from the Pacific versant of the Cordillera Occidental, its occurrence in the Middle Magdalena Valley is not unexpected. Many Central American species of reptiles that reach the western region of Colombia have also been reported to inhabit the middle region of the Magdalena Valley, such as *Rhinobothryum bovalli* (Andersson, 1916), *Diploglossus monotropis* (Kuhl, 1820), *Sibon annulatus* (Günther, 1872), *Imantodes inornatus* (Boulenger,1896) (Rojas-Morales 2012, Diaz-Ayala et al. 2015, Meneses-Pelayo et al. 2016, Echavarría et al. 2018). This exchange of fauna between the Choco region and the Middle Magdalena Valley is possible because of Pleistocene refuges of humid tropical rainforest (Hernández-Camacho et al. 1992).

Downs (1967) reports an unconfirmed specimen of *G. brachycephalus* (treating *G. nigroalbus* as a synonym species of *G. brachycephalus*) for the Cordillera Oriental in the department of Santander, Municipality of Landazuri (900 m a.s.l). Neither Myers (2003) nor Savage and Watling (2008) examined this specimen and the latter authors suggested that it could be an undescribed species of *Geophis*. The identification of our specimen, based on scutellation counts, coloration, and scale ornamentation, agrees with the diagnostic characters of *G.*

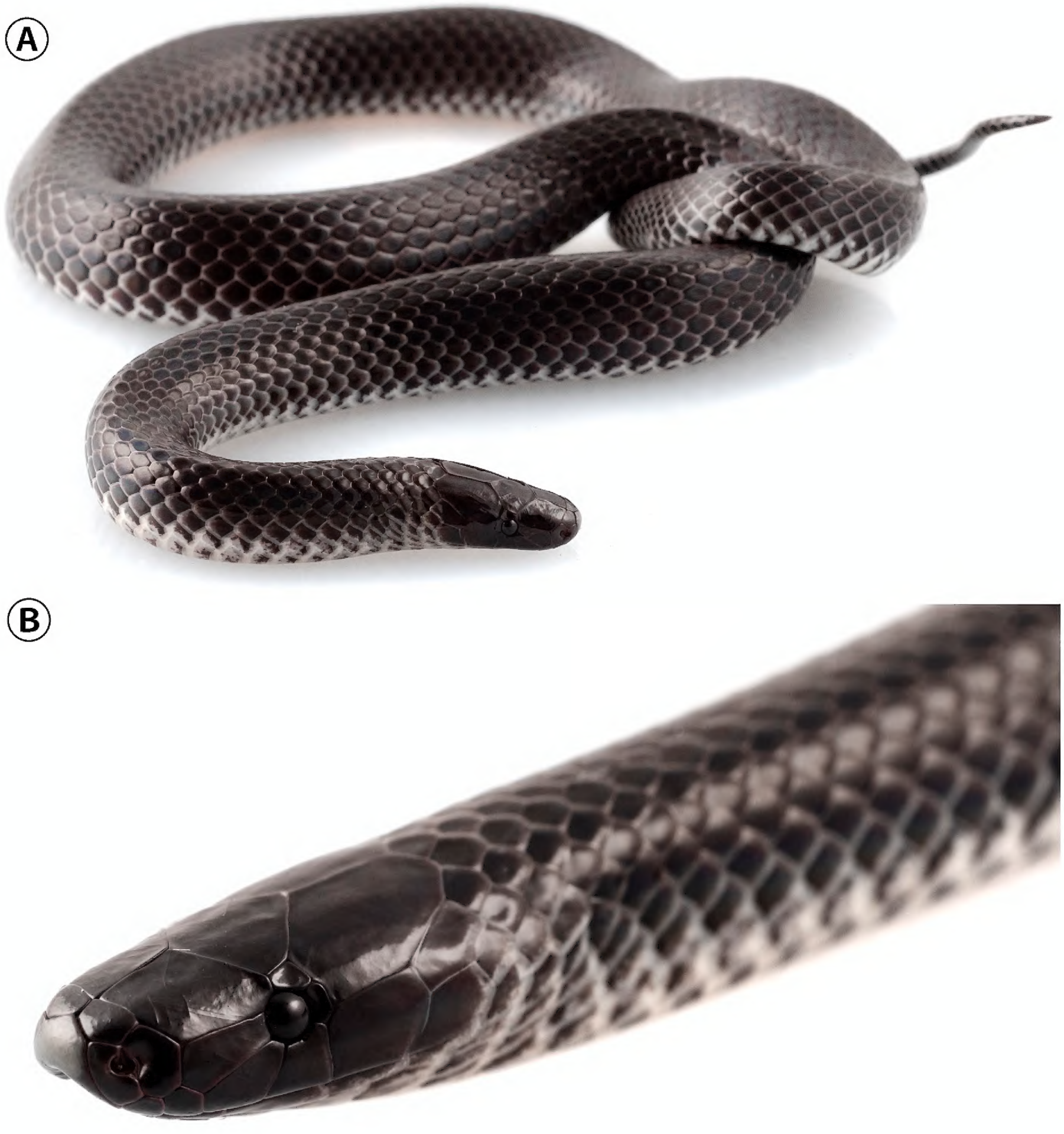

Figure 2. *Geophis nigroalbus* in life IAvH-R-9257, SVL 309 mm, TL 65 mm **A.** Dorsal view. **B.** Cephalic scales view. (Photographs: Felipe Villegas).

nigroalbus. Thus, we believe the specimen reported by Downs (1967) is probably an individual of *G. nigroalbus*.

The scarcity of *G. nigroalbus* in fieldwork and in collections makes this an important record to elucidate the geographic distribution and conservations status of this endemic fossorial snake. Wilson and Townsend (2007) categorized the conservation status of *Geophis* species based on the physiographic regions of Central America delimitated by Campbell (1999) and vegetation zones the species inhabit. *Geophis nigroalbus* was categorized as most vulnerable since its occurrence is restricted to Lower Montane Wet Forest in the Northern Andes. However, using the physiographic regions of South America proposed by Duellman (1999), this new report expands the occurrence of this species to the physiographic regions Choco and Andes. Thus, according to the conservation categories of Wilson and Townsend (2007), the conservation status of *G. nigroalbus* would be intermediately vulnerable. Nevertheless, we suggest that the conservation criteria of IUCN should be used to categorize the conservation status of the species.

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Authors' Contributions

DGC identified the specimen; DGC, ACG and APH wrote the manuscript; GCA and ARA reviewed the manuscript; ACG, DGC, APH and GCA collected the specimens and GCA retrieved ecological data.

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